METHODS AND APPARATUS FOR ACCESSING AND TREATING REGIONS OF THE BODY

FIELD OF THE INVENTION

[0001] The present invention relates generally to endoscopes and endoscopic medical procedures. More particularly, it relates to methods and apparatus for accessing and treating regions within the body which are difficult to reach through conventional surgical devices and procedures.

BACKGROUND OF THE INVENTION

[0002] Many surgical procedures typically require large incisions be made to provide access to regions within the body. For instance, operating on or near the posterior regions of the heart is ordinarily performed using open-chest techniques. Such a procedure generally requires a gross thoracotomy or sternotomy, which are both highly invasive and attendant with a great deal of risks, such as ischemic damage to the heart, formation of emboli, etc. A thoracotomy typically involves creating an incision in the intercostal space between adjacent ribs while a sternotomy involves the "chest spreader" approach, which is generally the most invasive. Moreover, such an invasive procedure produces significant morbidity, increased mortality rates, and significantly increases recovery time for the patient.

[0003] Minimally invasive surgery is an alternative surgical procedure in which small incisions are made in the patient's body to provide access for various surgical devices for viewing and operating inside the patient. Laparoscopes are typically used for accessing and performing operations within the body through these small incisions using specially designed surgical instruments. These instruments generally have handles which are manipulatable from outside of the patient's body by the surgeon to control the operation of the instrument typically through an elongated

tubular section which fits through a tube, introducer, or trocar device entering the patient's body.

[0004] However, even conventional laparoscopic procedures are limited in applicability in part because of a "straight-line" requirement in utilizing laparoscopic tools. This requirement makes accessing certain areas within the body extremely difficult, if not impracticable. Moreover, the lack of flexibility of these tools have made access to certain regions of the body difficult, forcing many surgeons to resort to open surgery rather than utilizing conventional minimally invasive procedures.

[0005] Flexible endoscopic devices are also available for use in minimally invasive surgical procedures in providing access to regions within the body. Flexible endoscopes are typically used for a variety of different diagnostic and interventional procedures, including colonoscopy, bronchoscopy, thoracoscopy, laparoscopy and video endoscopy. A flexible endoscope may typically include a fiberoptic imaging bundle or a miniature camera located at the instrument's tip, illumination fibers, one or two instrument channels that may also be used for insufflation or irrigation, air and water channels, and vacuum channels. However, considerable manipulation of the endoscope is often necessary to advance the device through the body, making use of conventional devices more difficult and time consuming and adding to the potential for complications.

[0006] Steerable flexible endoscopes have been devised to facilitate selection of the correct path though regions of the body. However, as the device is typically inserted farther into the body, it generally becomes more difficult to advance. Moreover, friction and slack in the endoscope typically builds up at each turn, making it more difficult to advance and withdraw the device. Another problem which may arise, for example, in colonoscopic procedures, is the formation of loops in the long and narrow tube of the colonoscope. Such loops may arise when the scope encounters an obstacle, gets stuck in a narrow passage, or takes on a shape that incorporates compound curves. Rather progressing, the scope forms loops within the

patient. In an attempt to proceed in insertion of the colonoscope, for example, excess force may be exerted, damaging delicate tissue in the patient's body. The physician may proceed with the attempted insertion of the endoscope without realizing there is a problem.

[0007] Through a visual imaging device the user can observe images transmitted from the distal end of the endoscope. From these images and from knowledge of the path the endoscope has followed, the user can ordinarily determine the position of the endoscope. However, it is difficult to determine the endoscope position within a patient's body with any great degree of accuracy.

[0008] None of the instruments described above is flexible enough to address the wide range of requirements for surgical procedures performed internally to the patient's body. Furthermore, the instruments described lack the ability to rotate the distal tip about the longitudinal axis of the instrument while fully articulating the tip to any setting relative to the tubular section of the instrument. This lack of flexibility requires surgeons to manually rotate and move the instrument relative to the patient body to perform the procedure.

BRIEF SUMMARY OF THE INVENTION

[0009] Endoscopic devices, as described below, may be particularly useful in treating various regions within the body. Such endoscopes may include a steerable distal portion and an automatically controlled proximal portion which may be controlled by a physician or surgeon to facilitate steering the device while the proximal portion may be automatically controlled by, e.g., a controller or computer. The steerable endoscope may be advanced within the body of a patient, e.g., via any one of the natural orifices into the body such as through the anus. Alternatively, the device may be introduced percutaneously through a small incision into the body. Once the endoscopic device has been introduced into the body, it may be advanced and maneuvered to avoid obstructing anatomical features such as organs, bones, etc.,

without impinging upon the anatomy of the patient. Examples of such devices are described in detail in the following patents and co-pending applications: U.S. Pat. No. 6,468,203; U.S. Pat. No. 6,610,007; U.S. Pat. App. No. 10/087,100 filed March 1, 2002; U.S. Pat. App. No. 10/139,289 filed May 2, 2002, U.S. Pat. App. No. 10/229,577 filed August 27, 2002; U.S. Pat. App. No. 10/229,814 filed August 27, 2002, and U.S. Pat. App. No. 10/306,580 filed November 27, 2002, each of which is incorporated herein by reference in its entirety.

[0010] Using such a device, one method of treating an obstructed region of tissue within a body, may generally comprise advancing an elongate device into the body through an opening, the elongate device having a proximal portion and a selectively steerable distal portion and the elongate device having a plurality of segments, selectively steering the distal portion to assume a selected curve along a desired path within the body which avoids contact with tissue (or does not require displacement of adjacent tissue along the desired path or avoids applying excess force to the adjacent tissue), and further advancing the elongate device through the body and towards the region of tissue to be treated while controlling the proximal portion of the device to assume the selected curve of the distal portion.

[0011] Using any one of the controllable endoscopic devices, various regions of the body which are typically difficult to access and treat through conventional surgical techniques, may be accessed and treated accordingly. In one treatment variation, the endoscopic device may be utilized for neurological surgical applications. Because the endoscopic device is unconstrained by "straight-line" requirements for accessing regions of the brain which are conventionally difficult to reach and/or because the device avoids forming loops when advanced, the endoscope may be accurately advanced and positioned within the cranium by steering the device around the brain with minimal or no trauma to healthy brain tissue. The endoscope may also be advanced through the tissue as necessary to access treatment areas embedded deep within the tissue through pathways which may minimize any damage

to healthy adjacent tissue. Furthermore, because the endoscopic device may allow access to sensitive regions over or within the brain, minimally invasive surgery may be performed where conventional surgery would normally require removal of portions of the skull, for instance, in craniotomy procedures or treatment of intracranial hematomas, etc. In addition, access through the nasal passages or other natural cranial orifices may be facilitated.

[0012] Another area of treatment in which the endoscopic device may be utilized may include use for coronary procedures, e.g., treatment of the mitral valve, tissue ablation for the treatment of atrial fibrillation, placement, removal, or adjustment of pacing leads, etc. In one example, the endoscopic device may be introduced within the heart via the superior vena cava and advanced through the right atrium. Once the endoscope is within the right atrium, the distal portion may be steered through the atrial septum and into the left atrium where the distal portion of the device may be positioned adjacent to the tissue to be treated, in this example, the mitral valve. To affect treatment, various tools or devices, e.g., scalpels, graspers, etc., may be delivered through one or several working channel within the device to effect the treatment.

[0013] In yet another area of treatment in which the endoscopic device may be utilized, various thoracoscopy procedures may be accomplished in a minimally invasive procedure, e.g., percutaneously. As shown, the endoscope may be advanced into the patient via an introducer or port, which may also be configured as a datum for establishing a fixed point of reference for the endoscope during the procedure. The port or datum may be in electrical communication with a computer or processor used for determining and/or maintaining the position of the device within the patient. The endoscope may be advanced into the body of the patient through an incision made, e.g., in the intercostal space between the ribs. The endoscope may then be advanced into the thoracic cavity and maneuvered to regions within the body such as

the posterior region of the heart which are normally inaccessible for conventional laparoscopic procedures due to a lack of straight-line access.

[0014] The endoscope device may also be utilized for procedures within the peritoneal cavity. Potential applications may include minimally invasive surgery for urologic, bariatric, and liver surgery. Moreover, minimally invasive access may be achieved for treatments in spinal or orthopedic surgery as well. In such a procedure, the endoscope may be introduced into the patient through an incision via a port, which may also function as a datum. The distal portion may be steered to avoid various organs while being advanced to a tissue region to be treated, e.g., the liver. The distal portion of the endoscope may accordingly be steered while the proximal portion may be automatically controlled to follow a path defined by the distal portion which minimizes contact with the surrounding and adjacent tissue and organs. In this or any other procedure, one or more laparoscopes may optionally be used in combination with the endoscope to assist with the surgical procedure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Fig. 1 shows one variation of a steerable endoscope which may be utilized for accessing various regions within the body without impinging upon the anatomy of the patient.

[0016] Fig. 2A shows a wire frame model of a section of the elongate body of the endoscope in a neutral or straight position.

[0017] Fig. 2B shows an illustration of the endoscope body maneuvered through a curve with the selectively steerable distal portion and automatically controlled proximal portion.

[0018] Fig. 3 shows a cross-sectional side view of a patient's head with a variation of the endoscope being advanced therethrough.

[0019] Fig. 4 shows a cross-sectional anterior view of a heart with the endoscopic device introduced via the superior vena cava and advanced to the right atrium.

[0020] Fig. 5 shows an example of a thoracoscopy procedure which may be performed percutaneously with the endoscopic device.

[0021] Figs. 6A to 6D show an example of the endoscopic device advanced to the posterior region of a heart for the treatment of atrial fibrillation.

[0022] Fig. 7 shows another example of a treatment for atrial fibrillation using the endoscopic device.

[0023] Fig. 8 shows yet another example of a treatment for atrial fibrillation using the endoscopic device.

[0024] Fig. 9 shows an example of a procedure within the peritoneal cavity which may be performed with the endoscopic device.

[0025] Figs. 10A to 10C shows side and end views, respectively, of various electrode configurations on the endoscope for tissue ablation treatment.

DETAILED DESCRIPTION OF THE INVENTION

[0026] In treating various regions within the body, a number of different endoscopic devices may be utilized in facilitating access. Endoscopic devices which are particularly useful may include various endoscopes having a steerable distal portion and an automatically controlled proximal portion. Generally, the steerable distal portion may be controlled by a physician or surgeon to facilitate steering the device while the proximal portion may be automatically controlled by, e.g., a controller or computer. The steerable endoscope may be advanced within the body of the patient through a number of different methods. For instance, the endoscope may be introduced via any one of the natural orifices into the body such as through the anus. Alternatively, the device may be introduced percutaneously through a small incision into the body. Once the endoscopic device has been introduced into the

body, it may be advanced and maneuvered, as described below, to avoid obstructing anatomical features such as organs, bones, etc., without impinging upon the anatomy of the patient.

[0027] Fig. 1 illustrates one variation of a steerable endoscope **100** which may be utilized for accessing various regions within the body without impinging upon the anatomy of the patient. The endoscope **100** generally has an elongate body **102** with a manually or selectively steerable distal portion **104** and an automatically controlled proximal portion **106**. The selectively steerable distal portion **104** may be selectively steered or bent up to a full 180° bend in any direction, as shown by the dashed lines. A fiberoptic imaging bundle **112** and one or more illumination fibers **114** may optionally be extended through the body **102** from the proximal end **110** to the distal end **108**. Alternatively, the endoscope **100** may be configured as a video endoscope with a miniaturized video camera, such as a CCD or CMOS camera, positioned at the distal end **108** of the endoscope body **102**. The images from the video camera may be transmitted to a video monitor by a transmission cable or by wireless transmission. Optionally, the body **102** of the endoscope **100** may also include at least one or two instrument channels **116**, **118** that may be used to provide access through the endoscope for any number of tools. Channels **116**, **118** may also be used for various other purposes, e.g., insufflation or irrigation.

[0028] The elongate body **102** of the endoscope **100** is highly flexible so that it is able to bend around small diameter curves without buckling or kinking. The elongate body **102** of the endoscope **100** may range in length typically from, e.g., 135 to 185 cm, and 12 to 13 mm in diameter. However, if the endoscope **100** were utilized in regions within the body which are smaller than the space within, e.g., the gastrointestinal tract, the device may be modified in size to be smaller in diameter. The endoscope **100** may also be modified in length to be longer or shorter, depending upon the desired application.

[0029] A handle **120** is attachable to the proximal end **110** of the elongate body **102**. The handle **120** may include an ocular **124** connected to the fiberoptic imaging bundle **112** for direct viewing and/or for connection to a video camera **126**. The handle **120** may also be connected to an illumination source **128** via an illumination cable **134** that may connected to or continuous with the illumination fibers **114**. An optional first luer lock fitting **130** and an optional second luer lock fitting **132**, which may be in communication with instrument channels **116**, **118**, respectively, may also be located on or near the handle **120**.

[0030] The handle **120** may be connected to an electronic motion controller **140** by way of a controller cable **136**. A steering control **122** may be connected to the electronic motion controller **140** by way of a second cable **138**. The steering control **122** may be configured to allow the physician or surgeon to selectively steer or bend the selectively steerable distal portion **104** of the elongate body **102** in the desired direction. The steering control **122** may be a joystick controller as shown, or other known steering control mechanism. Alternatively, the steering may be effected manually, e.g. by the use of cables, hydraulics, or pneumatics, or any other known mechanical apparatus for controlling the distal portion of the elongate body. The electronic motion controller **140** may be used to control the motion of the automatically controlled proximal portion **106** of the elongate body **102** and may be implemented using a motion control program running on a microcomputer or through an application-specific motion controller. Alternatively, the electronic motion controller **140** may be implemented using a neural network controller.

[0031] An axial motion transducer **150** may be provided to measure the axial motion of the elongate body **102** as it is advanced and withdrawn. The axial motion transducer **150** can be made in many configurations, some of which are described below. In this variation, the axial motion transducer **150** is configured as a ring **152**, for illustrative purposes only, that surrounds the elongate body **102** of the endoscope **100**. The axial motion transducer **150** may be attached to a fixed point of reference,

such as the surgical table or the insertion point for the endoscope **100** on the patient's body, as described below. As the body **102** of the endoscope **100** slides through the axial motion transducer **150**, it produces a signal indicative of the axial position of the endoscope body **102** with respect to the fixed point of reference and sends a signal to the electronic motion controller **140** by telemetry or by a cable (not shown). The axial motion transducer **150** may use optical, electronic, magnetic, mechanical, etc., methods to determine the axial position of the endoscope body **102**. In addition, the motion transducer may be configured to simultaneously measure and communicate rotational motion of the endoscope, so that this additional data may be used in the control of the instrument's motion. A further detailed description for the axial motion transducer **150** and variations thereof may be found in U.S. Pat. App. No. 10/384,252 filed March 7, 2003, which is incorporated herein by reference in its entirety.

[0032] To illustrate the basic motion of the endoscope **100**, Fig. 2A shows a wire frame model of a section of the body **102** of the endoscope **100** in a neutral or straight position. Most of the internal structure of the endoscope body **102** has been eliminated in this drawing for the sake of clarity. The endoscope body **102** is divided up into sections 1, 2, 3 . . . 10, etc. The geometry of each section is defined by four length measurements along the a, b, c and d axes. For example, the geometry of section 1 may be defined by the four length measurements l_{1a}, l_{1b}, l_{1c}, l_{1d}, and the geometry of section 2 may be defined by the four length measurements l_{2a}, l_{2b}, l_{2c}, l_{2d}, etc. The geometry of each section may be altered using the linear actuators to change the four length measurements along the a, b, c and d axes. For example, to bend the endoscope body **102** in the direction of the a axis, the measurements l_{1a}, l_{2a}, l_{3a} . . . l_{10a} can be shortened and the measurements l_{1b}, l_{2b}, l_{3b} . . . l_{10b} can be lengthened an equal amount. The amount by which these measurements are changed determines the radius of the resultant curve. In the automatically controlled proximal portion **106**, however, the a, b, c and d axis measurements of each section may be automatically controlled by the electronic motion controller **140**.

[0033] In Fig. 2B, the endoscope body **102** has been maneuvered through the curve **C** with the benefit of the selectively steerable distal portion **104** and now the automatically controlled proximal portion **106** resides in the curve **C**. Sections 1 and 2 are in a relatively straight part of the curve C, therefore $l_{1a} = l_{1b}$ and $l_{2a} = l_{2b}$. However, because sections 3-7 are in the S-shaped curved section, $l_{3a} < l_{3b}$, $l_{4a} < l_{4b}$ and $l_{5a} < l_{5b}$, but $l_{6a} > l_{6b}$, $l_{7a} > l_{7b}$ and $l_{8a} > l_{8b}$. When the endoscope body **102** is advanced distally by one unit, section 1 moves into the position marked 1', section 2 moves into the position previously occupied by section 1, section 3 moves into the position previously occupied by section 2, etc. The axial motion transducer **150** produces a signal indicative of the axial position of the endoscope body **102** with respect to a fixed point of reference and sends the signal to the electronic motion controller **140**. Under control of the electronic motion controller **140**, each time the endoscope body **102** advances one unit, each section in the automatically controlled proximal portion **106** is signaled to assume the shape of the section that previously occupied the space that it is now in. Therefore, when the endoscope body **102** is advanced to the position marked 1', $l_{1a} = l_{1b}$, $l_{2a} = l_{2b}$, $l_{3a} = l_{3b}$, $l_{4a} < l_{4b}$, $l_{5a} < l_{5b}$, $l_{6a} < l_{6b}$, $l_{7a} > l_{7b}$, $l_{8a} > l_{8b}$, and $l_{9a} > l_{9b}$, and, when the endoscope body **102** is advanced to the position marked 1'', $l_{1a} = l_{1b}$, $l_{2a} = l_{2b}$, $l_{3a} = l_{3b}$, $l_{4a} = l_{4b}$, $l_{5a} < l_{5b}$, $l_{6a} < l_{6b}$, $l_{7a} < l_{7b}$, $l_{8a} > l_{8b}$, $l_{9a} > l_{9b}$, and $l_{10a} > l_{10b}$. Thus, the S-shaped curve propagates proximally along the length of the automatically controlled proximal portion **106** of the endoscope body **102**. The S-shaped curve appears to be fixed in space, as the endoscope body **102** advances distally.

[0034] Similarly, when the endoscope body **102** is withdrawn proximally, each time the endoscope body **102** is moved proximally by one unit, each section in the automatically controlled proximal portion **106** is signaled to assume the shape of the section that previously occupied the space that it is now in. The S-shaped curve propagates distally along the length of the automatically controlled proximal portion

106 of the endoscope body **102**, and the S-shaped curve appears to be fixed in space, as the endoscope body **102** withdraws proximally.

[0035] Whenever the endoscope body **102** is advanced or withdrawn, the axial motion transducer **150** may be used to detect the change in position and the electronic motion controller **140** may be used to propagate the selected curves proximally or distally along the automatically controlled proximal portion **106** of the endoscope body **102** to maintain the curves in a spatially fixed position. Similarly, if the endoscope **102** is rotated, a rotational motion transducer (separate from or integrated within transducer **150**) may be used to detect the change in position and the electronic motion controller may be similarly used to adjust the shape of the endoscope body **102** to maintain the curves in a spatially fixed position. This allows the endoscope body **102** to move through tortuous curves without putting unnecessary force on the wall of the curve **C**.

[0036] Examples of other endoscopic devices which may be utilized in the present invention are described in further detail in the following patents and co-pending applications, U.S. Pat. No. 6,468,203; U.S. Pat. No. 6,610,007; U.S. Pat. App. No. 10/087,100 filed March 1, 2002; U.S. Pat. App. No. 10/139,289 filed May 2, 2002, U.S. Pat. App. No. 10/229,577 filed August 27, 2002; U.S. Pat. App. No. 10/229,814 filed August 27, 2002, and U.S. Pat. App. No. 10/306,580 filed November 27, 2002, each of which has been incorporated herein by reference above.

[0037] Therefore, using any one of the controllable endoscopic devices described above, various regions of the body which are typically difficult to access and treat through conventional surgical techniques, may be accessed and treated accordingly. In one treatment variation, the endoscopic device may be utilized for neurological surgical applications. Because the endoscopic device is unconstrained by "straight-line" requirements for accessing regions of the brain which are conventionally difficult to reach, the endoscope may be advanced and positioned within the cranium by steering the device around the brain with minimal or no trauma

to healthy brain tissue. The endoscope may also be advanced through the tissue as necessary to access treatment areas embedded deep within the tissue through pathways which may minimize any damage to healthy adjacent tissue. Furthermore, because the endoscopic device may allow access to sensitive regions over or within the brain, minimally invasive surgery may be performed where conventional surgery would normally require removal of portions of the skull, for instance, in craniotomy procedures or treatment of intracranial hematomas, etc.

[0038] Fig. 3 shows a cross-sectional side view of head **202** of patient **200**. The brain **206** may be seen within the cranial cavity **210** of cranium **204**. In treating regions of the brain **206** which may be difficult to normally access, the endoscopic device **212** may be introduced into the cranial cavity **210** from an easily accessible insertion site **222**, e.g., a perforation within the skull. The endoscope **212** may be then advanced through the insertion site **222** by controlling the steerable distal portion **214** to avoid brain tissue. As the endoscope **212** is further advanced into the cranial cavity **210**, the automatically controlled proximal portion **216** may attain the shape defined by the steerable distal portion **214** to avoid contact with brain tissue **206**.

[0039] The endoscope **212** may be further advanced through the cranial cavity **210** and within the cerebrospinal fluid so that the device is advanced above or within the layers of the meninges, e.g., within the subarachnoid space. In either case, the endoscope **212** may be steered along a path which avoids or minimizes contact or pressure against the brain tissue **206**. As the controlled proximal portion **216** is advanced distally and attains the shape defined by the distal portion **214**, the proximal portion **216** likewise may be controlled to automatically avoid or minimize contact or pressure against the brain tissue **206**. Once the distal portion **216** is advanced to the desired treatment region **208**, various tools **220** may be introduced through the instrument channel **218** to enable treatment of the region **208**. Any number of treatments or procedures may accordingly be effected, e.g., tumor biopsy and/or

removal, shunt placement, lead placement, device placement, drainage of excess cerebrospinal fluid or blood, etc.

[0040] Another area of treatment in which the endoscopic device may be utilized may include use for coronary procedures, e.g., treatment of the mitral valve, tissue ablation for the treatment of atrial fibrillation, the placement, repositioning or removal of device leads, etc. As shown in Fig. 4, a cross-sectional anterior view of heart **302** may be seen in coronary procedure **300** for treatment of the mitral valve **MV** located between the left atrium **LA** and the left ventricle **LV**. The endoscopic device **212** is shown in this treatment variation as being introduced within the heart **302** via the superior vena cava **SVC** and advanced through the right atrium **RA**. Also shown is the right ventricle **RV** below the tricuspid valve **TV** and inferior vena cava **IVC**. The endoscope **212** may be sized accordingly to be delivered intravascularly. Once the endoscopic device **212** is within the right atrium **RA**, the distal portion **214** may be steered towards the atrial septum **AS** which separates the left atrium **LA** and right atrium **RA**. Once at the atrial septum **AS**, a cutting tool deliverable through the device **212** may be used to perforate the atrial septum **AS** to allow passage of the endoscopic device **212** into the left atrium **LA**. The distal portion **214** may then be steered and positioned adjacent the mitral valve **MV** while the proximal portion **216** is automatically controlled to minimize any pressure which may be exerted by the device **212** against the tissue of the heart **302**. Once the endoscopic device is adjacent to the tissue to be treated, in this example the mitral valve **MV**, various tools or devices may be delivered through the channel **218** to effect the treatment. Once the procedure has been completed, the endoscope **212** may simply be withdrawn proximally in the same manner while minimizing any contact pressure against the tissue.

[0041] In yet another area of treatment in which the endoscopic device may be utilized, various thoracoscopy procedures may be accomplished in a minimally invasive procedure. Fig. 5 shows an example of a thoracoscopy procedure **400** which

may be performed percutaneously. As shown, the endoscope **212** may be advanced into the patient **402** via an introducer or port **412**, which may also be configured as a datum for establishing a fixed point of reference for the endoscope **212** during the procedure. The port or datum **412** may be in electrical communication via electrical lines **418** with a computer or processor **416** which may be used for determining and/or maintaining the position of the device **212** within the patient **402**. The endoscope **212** may be advanced into the body of the patient **402** through an incision **414** made, e.g., in the intercostal space between the ribs **404**. The endoscope **212** may then be advanced into the thoracic cavity and maneuvered to regions within the body such as the posterior region of the heart **408** which are normally inaccessible for conventional laparoscopic procedures due to a lack of straight-line access.

[0042] In this example, the endoscopic device **212** is shown having been inserted through port or datum **412** and advanced posteriorly of heart **408** behind sternum **406**. The lungs are not shown for the sake of clarity; however, the endoscope **212** may be steered and advanced around the lungs in a manner described above so as to avoid contact or to minimize contact with the lung tissue or any other organs or structures which may be obstructing a straight-line path.

[0043] The endoscopic device **212** is capable of reaching regions within the body, without damaging surrounding tissue, which is normally inaccessible via conventional laparoscopic procedures. Yet another procedure **500** is shown in Figs. 6A to 6D, which illustrate how the endoscopic device may be utilized for the treatment of atrial fibrillation. The figures show a posterior view of the heart with the aorta **AA** and pulmonary trunk **PT** as anatomical landmarks. Atrial fibrillation is typically sustained by the presence of multiple electrical reentrant wavelets propagating simultaneously in the atria of the heart. Surgical and catheter-based techniques typically place segmented or continuous lesions near and around the pulmonary veins as one way to re-synchronize the atria.

[0044] The endoscopic device **212** may be utilized by advancing the device **212** into the thoracic cavity, as described above or through various other channels, and steered towards the posterior region of the heart. In the example shown in Figs. 6A to 6D, the steerable distal portion **214** may be advanced as shown in Fig. 6A such that the endoscope **212** approaches above the left pulmonary veins **LPV**. As shown in Fig. 6B, the distal portion **214** may be steered around the right pulmonary veins **RPV** while the endoscope **212** is advanced distally. The automatically controllable proximal portion **216** may thus assume the shape defined by the distal portion **214** in traversing around the pulmonary vessels. As shown in Fig. 6C, the distal portion **214** is steered around the left pulmonary vessels **LPV** while the proximal portion has assumed the curved path traversed by the device around the right pulmonary vessels **RPV**. Finally in Fig. 6D, the device **212** may be fully advanced entirely around the pulmonary vessels such that the distal portion **214** and proximal portion **216** are in intimate contact against the heart tissue while maintaining its configuration. The tissue which is in contact against the device **212** may then be ablated by one or several electrodes located along the length of the distal and/or proximal portions **214**, **216**, as described in further detail below. Alternately, an ablation device such as a catheter or other energy source, may be delivered through one or more working channels in or on the endoscope, and left in place as desired. This ablation device may then be used to deliver ablative energy in various forms, e.g., RF, microwave, cryogenic cooling, etc. The device may be held fixedly in the desired location by various methods, e.g., vacuum, magnetically, temporary adhesives, sutures, or any other methods of attaching or approximating the device and tissue.

[0045] Fig. 7 shows another variation **600** of treating atrial fibrillation where the device may be steered and configured to loop in a continuous manner about the pulmonary vessels in a first encirclement **602** over the left pulmonary vessels **LPV** and a second encirclement **604** over the right pulmonary vessels **RPV**. The encircled portions **602**, **604** of the endoscope **212** may be activated to ablate the heart tissue

only around the pulmonary vessels **LPV**, **RPV** or alternatively, it may be activated to ablate the heart tissue along the entire length of both distal portion **214** and proximal portion **216**. Moreover, a variety of ablation devices may be delivered to the desired areas, as described above.

[0046] Fig. 8 shows yet another variation **700** in which the endoscope **212** may be advanced and steered to contact the portions of tissue posteriorly adjacent to the pulmonary vessels **LPV**, **RPV** such that an encircled region is formed **702**. The endoscope **900** may be configured with a number of electrodes over its outer surface to facilitate the tissue ablation along the length, or selected regions of length, of the endoscope, as shown in Fig. 10A. The figure shows the steerable distal portion **904** and part of the automatically controllable proximal portion **902** as one example of electrode placement over the endoscope **900**. As seen, one or any number of electrodes **906** may be circumferentially positioned, e.g., ring-shaped, along the length of endoscope **900** at intervals. The electrodes **906** are shown positioned at uniform intervals in this variation; however, they may be configured in any random, arbitrary, or specified locations over the outer surface of the endoscope **900**. Each of the electrodes **906** may be electrically connected via corresponding wires **908** to a power supply and/or controller. Thus, all the electrodes **906** may be configured to operate simultaneously or to operate only selected electrodes **906** which may be in contact with tissue. In yet another variation, various ablation devices may be delivered to the desired areas, again as described above.

[0047] Fig. 10B shows another variation in endoscope **910** in which electrodes **916** may be configured to extend longitudinally over the proximal portion **912** and/or distal portion **914**. The electrodes may be configured to extend in a continuous strip along the endoscope length or the electrodes **916** may be alternatively configured to extend in a segmented manner longitudinally over the endoscope **910**, as shown. Having segmented electrodes **916** may allow for selected electrodes to be activated during tissue ablation. Although Fig. 10B shows a single

line of electrodes **916** for illustration purposes, multiple lines of electrodes may be positioned over the outer surface of the device, as shown in the example of Fig. 10C, which illustrates multiple lines of electrodes **918** spaced uniformly around the circumference of the endoscope surface.

[0048] These examples described above are intended to be illustrative and are not intended to be limiting. Any number of other configurations may be accomplished with the endoscopic device due to the ability of the device to steer and configure itself such that excessive contact with surrounding tissue is avoided. Moreover, access to any number of various regions within the thoracic cavity with minimal or no damage to surrounding tissue and organs may be accomplished using the controllable endoscopic device above. Other examples for treatment using the endoscope may include, but not limited to, lead placement, implantable device placement, treatment on the lungs such as emphysema treatments, etc.

[0049] The endoscope device may also be utilized for procedures within the peritoneal cavity. Potential applications may include minimally invasive surgery for urologic, bariatric, and liver surgery. Moreover, minimally invasive access may be achieved for treatments in spinal or orthopedic surgery as well. Fig. 9 shows an example of a procedure **800** within the peritoneal cavity using the endoscopic device **212**. The endoscope **212** may be introduced into patient **802** through an incision **808** via a port, which may also function as a datum **806**, as described above. The distal portion **214** may be steered to avoid various organs while being advanced to a tissue region to be treated, in this example, the posterior region of liver **804**. The distal portion **214** of the endoscope **212** may accordingly be steered while the proximal portion **216** may be automatically controlled to follow a path defined by the distal portion **214** which minimizes contact with the surrounding and adjacent tissue and organs. One or more laparoscopes **810** may optionally be used in combination with the endoscope **212** to assist with the surgical procedure. Once the distal portion **214** is posteriorly positioned of the liver **804**, various tools or treatment devices may be

advanced through the endoscope **212** from the proximal end to effect the desired treatment. Although this example shows treatment of the liver **804** using the endoscope **212**, this is intended to be illustrative and other organs or procedures may be effected using the endoscope **212**.

[0050] The applications of the devices and methods discussed above are not limited to regions of the body but may include any number of further treatment applications. Other treatment sites may include other areas or regions of the body. Additionally, the present invention may be used in other environments such as exploratory procedures on piping systems, ducts, etc. Modification of the above-described assemblies and methods for carrying out the invention, and variations of aspects of the invention that are obvious to those of skill in the art are intended to be within the scope of the claims.